

## **High Frequency Content in Seismic, Nonlinear Soil Analysis**

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Detailed guidance on linear soil-structure interaction (SSI) seismic analysis is provided in “Seismic Analysis of Safety-Related Nuclear Structures and Commentary (ASCE 4, 1998),” which is currently under revision. A new Appendix in ASCE 4-2017 (draft) is being added to provide guidance for nonlinear SSI (NLSSI) seismic analysis.

Currently, under the guidance in ASCE 4 (1998), seismic wave passage through soil is performed using linear techniques (with software such as SHAKE or SASSI). For seismic wave passage through nonlinear soil, hysteretic soil constitutive models can be implemented (using software such as LS-DYNA or Abaqus). One notable difference in soil wave passage between linear and nonlinear techniques is that the nonlinear techniques typically show additional high frequency content. A study is performed to better understand this high frequency content difference. The study is performed in three parts. First, a deep nonlinear soil column with reasonable soil material properties is evaluated with an actual rock outcrop seismic time history. This is performed to demonstrate that the nonlinear techniques do not produce an unreasonable amount of high frequency content under reasonable circumstances. Second, single element results are studied to show why high frequency content in addition to that shown with linear techniques should be expected in actual soil. Third, erroneous nonlinear model high frequency content is studied. The erroneous high frequency is shown to occur based on the nonlinear soil constitutive model definition. Also, ways to manage/minimize this error are shown.